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Chapter 5

Peat Use in Horticulture

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Abstract

Peat is a spongy substance which is an effect of incomplete decomposition of plant residues in different stages of decomposition. Between the several organic matters which are used as substrate for horticultural plants cultivation in soilless conditions, peat is the unabandonable ingredient for mixtures for commercial production of plants. Peat is used in horticulture as a component of garden plant substrates, in agriculture for the production of garden soil and as an organic fertilizer, and in balneology as a material for baths and wraps. The use of peat for agriculture and horticulture is determined by the following quality parameters: the degree of decomposition, ash content, pH, the presence of carbonates, the density of the solid phase, bulk density, and porosity. As an organic material, the peat forms in the acidic, waterlogged, and sterile conditions of fens and bogs. The conditions seem like the development of mosses. The plants do not compose as they die. Instead of this, the organic matter is laid down and accumulates in a slow time as peat due to the oxygen deficiency in the bog. This makes peat a highly productive growing medium. In the present novel review, we discuss the peat use in horticulture.

Keywords: plant, horticulture, growth, medium, peat

1. Introduction

The crops under systems of modern cultivation which is dealing with soilless culture consume substrates in organic and inorganic forms for nutrition of nutrient solutions. In general for the greenhouse plants, this system is used to maximize the productivity of crops and utilizing from all inputs in an efficient way for commercial production. In precious crop production, soilless culture systems in greenhouses are advised as alternative system to conventional production. For controlled conditions in the growth field, this conservated system is used. Due to this system, horticultural plants are increased by yield in soilless culture compared to culture of conventional soil. For increasing development of plants, the artificial system supports plants via mechanical instruments [1].

To gain much quality and more productivity in crops, ornamental and greenhouse plants, peat is used for a fast production. In some areas, the soils are not convenient for intensive production of plants, and due to this, container media are used in agriculture of greenhouse. The common media used for the systems in Northwest Europe and Israel are peat [2, 3].

Peat is based on organically decomposed matter and mostly plant originated. It composes from accumulation of nutrient and oxygen imperfection, acidity and waterlogging conditions. Also peat is composed from mosses, shrubs, small trees, and herbs in low temperatures like subarctic and boreal regions which reduce the decomposition ratio [4]. In the humid tropical conditions, the peat is composed from the trees of rainforest [5].

Peat has important functions for plant. It keeps water and nutrients, and gives them steadily to plants. It has air pockets or pores to supply oxygen to plant roots and allow for drainage. It is slight, clean, sterile, and does not include foreign material. Peat is one of the most important growing medium that is safe and cost-effective used in the production of horticulture plants. It is valuable for horticulture plants, because the peat has a good capacity to hold air and water in high quantities of available formed plant nutrients. The plant growth is supported by peat via providing appropriate conditions. The peat is a very clean medium that has no weeds or pathogens inside and also has comfortable storage conditions and very economical to buy. The peat also enables the media for several applications with its low pH and nutrient content. It has an important structural characteristic that is long constant even under intensive use and it is biodegradable [6]. Peat has perfect powers of absorption that absorbs water up to approximately 20 times its own dry weight, and can also pull oil [7]. It can be used as a very good heat insulator for dry peat. It can pick up various chemicals such as nutrients and pollutants. It is a perfect growth substrate for greenhouse crops, trees or vegetable seedlings, and potted ornamental plants. Also, it can improve garden soils [7].

The fields of usage of peat are as follows: (1) it is used for energy like fuel heat production and electricity for industrial or residential or other aims; (2) used for agricultural or horticultural aims like compost content or growth medium; and (3) used also for chemical and organic products like activated carbon, medicinal products like antibiotics, or therapeutic applications like baths of peat [8].

2. Historical use of peat in horticulture

Peat is an organic sheet composed in watery ecosystems where the local vegetation is being decayed. Peat lands are among the few available ecosystems that produce long-term energy [7]. For a long time, peat has been used for as absorbing urine in stables or as a great and dirty fuel. However, the most common use of peat has been for agriculture, pasture, and forestry [7].

Peat for fuel has been extracted in Europe since time immemorial, and the systematic industrialized extraction of peat for commercial purposes dates back to the thirteenth century; the peat is extracted for the purpose of fuel usage but in the last quarter of nineteenth century, this trend has declined by leaving its place to coal. And then, the initial form of peat was the peat moss litter. It is composed from white peat which is used to bedding for cattle and horses. Next form of peat in industry was active carbon which is sourced by black peat. The only active carbon factory which uses the peat as raw matter is The Purit (Norit) factory and is a part of the Cabot Corporation, nowadays. The other form of peat is potting soil and garden peat. This is also a common process in production of peat which has started in the late 1890s. In the history, there are two production types in peat factories such as peat cardboard and clothing. Allagnou from France was founded a factory to produce fibers from peat in 1884. Also, felt is made from this fiber matter. Due to low quality of products, the numbers of customers of Allagnou's were declined and the factory was closed. Another Frenchman, Beraud, took over the machinery and tried elsewhere in the country, but also met with little success. After 1992, the extraction of peat in The Netherlands was stopped due to usage of peat lands for energy and industrial production purposes. Nevertheless, the production and extraction of peat continues still in some part of the world for horticultural purposes in Europe, and it is a big player in the growth media and composting fields [9].

Lawrence and Newell were the creators of standardized growing media for commercial purpose in 1930, UK [2]. A mixture called "John Innes" includes some blends of loam, sand, and peat. Somehow, the quality of loam was hard to determine and the cost of transport of heavy mixtures was very high and this situation made an obstacle for growing horticultural industry [10].

At the beginning of 1950s due to widening of crop production in greenhouses and containerized nursery, there have been many studies and researches started to find and develop components for container-grown plant substrates. In the middle of twentieth century, for producing the containerized crops, the producers started to use sand, mined soil, and Canadian Sphagnum peat in the US mined soil [11]. With the developing technology, the producers started to use drip irrigation system with the combination of liquid fertilizer which made the producing, harvesting, and transport much more cheaper and easier and then, this business became a profitable way. In the US, the optimum soilless component was determined as bark and peat for crops growing in short or long periods in 1950s [12].

In UK, the usage of peat proportion in media was declined in 10 years duration [13], but it was really slow that there is approximately 3 million m^3 peat usage still continuing. The several obstacles like cost, quality and technical problems provide high proportion usage of peat in media [14].

With the increasing amount of soilless cultures in the world in the last years, the general forms of peats were started to use as peat-lite and bark and wood chips mixture for growing media in the container systems [1].

When we look at the historical dimension of growing media development, as an example, in Germany, it has been used in many different steps like below. Initially, in 1950s, the gardening soil has been used by horticulturists and there has been several components like their composted organic waste and mineral soil used in these mixtures. Also, in the plants with the bare roots or ball rooted plants, the mixtures were commonly used. Clay has been added in the mixture of peat culture substrates in 1950s and also the mixture developed alone without adding clay. The distribution of these substrates took place in1960s and the main component of in these growing media becomes peat. For the vegetable production in the West Europe, the rock wool becomes popular and distributed in the late of 1970s. The comfort of the usage of rock wool cubes and slabs provides producing private mixtures with better properties for plant species between the 1980s and 1990s. Approximately, the annual usage of peat in media now is between 77 and 80% in the Europe industry of horticulture [15].

3. Advantages of peat as growing media in horticulture

A suitable substrate is required for plant seed germination and emergence. This medium allows for the optimal development of plants in pot [16–18].

Different media are used in plant cultivation. These are organic matters like several origins of compost, chips of woods, barks and fibers from coconuts, agro industrial by-products, peat, dehydrated moss, and inorganic materials such as rock wool, vermiculite, and perlite [18–20]. Especially, peat has optimal quality features and it is the most used substrate in seedbed for seedling. In general, the tree and underglass cultivation and container shrubs use the greenhouse potting or nursery soil as growing media and peat becomes a substrate [21].

The growing media must provide oxygen and water supports for plant growth and efficient supply of continuous water system without cutting the oxygen to the plant roots. For a good rooting substrate in propagation, the most appropriate conditions should carry the convenient amounts of air and water and pH for nutrient uptake [22].

The peat becomes the main component for containerized mixture in commercial production and also very good component for vegetable and ornamental growing media when compared with all other organic materials for horticultural crops due to its several physical properties like high porosity and water holding capacity (WHC), slow degradation ratio, and low bulk density, and also good chemical properties like high cation exchange capacity (CEC) [23].

Now, more than a half century, the peat has been used for a substrate of horticulture due to its appropriate conditions like low nutrient status and pH. The reason is that the producers the needed dosages of nutrients for each plant's requirement. Moreover, peat provides a balanced aeration to roots and water with its high water holding capacity and aeration properties, that is why, peat substrates do not require precise irrigation schedule. According to data, peat use by sector in UK is 32% for container nursery stock (280,000 m^3), mushrooms 30% (260,000 m^3) bedding plants 16% (143,000 m^3) and other sectors such as pot plants, vegetable transplants, glasshouse salads, and bulbs follow. Smaller amounts of peat are also used for soft fruit and cut flower production. A very important characteristic of peat is that not many changes occur during the storage period. This fact is very important for growing media. An experiment which took place in Nottingham Trend University investigated changes in organic growing media during storage [24]. Alternative substrates such as paper and timber waste, bark, and wood fires have a high percentage of cellulose and hemicellulose. Due to the action of microorganisms, structural collapse may occur. Another problem that may appear is the development of molds or microbial organisms and the utilization of nutrients, especially nitrogen. Coir is another alternative substrate that can be used without these problems. Coir, like peat, has a high percentage of lignin; so, it is quite resistant to microbial degradation, but in order to use other substrates, certain measures should be taken. It is essential to have a very careful composting procedure for materials such as bark and timber by-products [25].

4. Peat physical properties

Peat is used extensively as an appropriate media for big quantities of vegetables because of its favorable physical properties, slow degradation rate, and relatively high CEC [23]. The positive effect of the physical properties in peat medium is the continued long period. The physical properties of peat include total porosity, pore sizes, water retention, bulk density, etc. In a media, high ratio retention of easily available water and providing good aeration for respiration of roots are considered the most important physical properties that needed to promote optimal plant and seedling growth. The deficiency of oxygen in a growth media with low aeration pores weakens root enlargement when low gas exchange occurs and consequently slows down plant growth. Aeration porosity for horticultural use should be ideally of minimum 20–25% [22, 26]. The desired value is up to 45% in warm greenhouse conditions because of increased oxygen requirement of the roots and also the rise in carbon dioxide production [27].

The physical properties of peat are related to source and degree of decomposition of the peat-forming vegetation. Generally, peat is an organic material with low bulk density, particle density, and too high porosity [28]. Particle density is relatively low, usually ranging from 1.0 to 1.6 [29]. The bulk density of the peat commonly used varies from mostly 0.05 to 0.200 g cm^{-3}. It can also increase to 0.500 g cm^{-3} depending on the types of plant residues and their decomposition. The total porosity in the peat reaches up to 80–90% and even a bit more due to dominantly low bulk density values despite less particle density. As the peat particle size distribution increases, water retention capacity decreases and the aeration volume increases. The water retention capacity at 1 kPa in peat is about 45–55% as the volume, while more decompose peat retains higher water 4–8 fold on the dry weight [30]. Aeration volume and water amount hindered at several tensions are the function of total porosity and the distribution of pore sizes of the media for plant growth. The total porosity of a growth media is the sum of the macro-, meso-, micro-, and spaces of ultramicropores [31]. The aeration and drainage is supplied when the macropores are larger than 100 μm in diameter, the mesopores are 100–30 μm in diameter for water conductivity, and the micropores are 30–3 μm in diameter to supply retention of water. The water in the ultramicropores with less than 3 μm diameter is not useful for plants. The results of many studies showed that peat provided high macropore volumes (45–50%) and also greater water volumes (40–45%) at low tensions (<1 kPa) [31–34]. Moreover, the mixed mediums containing peat have more water holding capacity in the root zone and create a more aerated environment.

5. Peat chemical properties

In general, approximately 80–90% of a fresh peat sample is composed of water and the remaining of solid material. The solid material has most of the components as organic and only 2–10% as inorganic.

6. Peat organic properties

The vegetative part of peat, and to less extent the microbial sources, includes organic residues [35, 36]. Due to complex chemical structure of peat, it contains very huge organic compounds. Additionally, there are several types of peat from bog to bog. Also, chemical composition may show changes with depth in the same bog. The organic composition of peat is effected by the peat position of decomposition, drastically. The elemental composition of peat change is given in table below as decomposition function. The microbial degradation of vegetative material in peat leads to 10% increase in the carbon content of peat from 50% at H1–H3 to 60% at H8–H10. The oxygen decrease in peat leads to 10% decrease via ascending humification approximately 43% at H1–H3 and 33% at H8–H10. N (nitrogen) and S (sulfur) have little increase, while H (hydrogen) is static, roughly.

Each element percentage in **Table 1** is taken from the dried organic material part of sample, and while the decomposition is proceeding, inclusion of several organic materials reduces [37]. In the highly decomposed peats, the microorganisms in the soil degrade the materials into hemicellulose and cellulose. The degraded matters like hemicellulose and cellulose is shown at H9–H10. The degradation occurs slowly in some high-resistant materials such as lignin, and at the end, these materials stay as decomposed in significant amounts. In the process of humification, the degradation occurs, and it is not only loss of matters. Humic acids and bitumen ratios are increasing as seen in **Table 2**. Humic acid constitutes approximately 60% of organic material. In **Table 2**, also ascending N compound amounts from microbial sources are shown.

Although the humification level is not effective, the derived plant matter from peat has some effects on chemical property. The effect on peat of plant is shown in **Table 3**.

Element	H 1 to H 3	H 4 to H 7	H 8 to H 10
Carbon (%)	48-53	56-58	59-63
Hydrogen (%)	5 0-6 1	5 5-6 1	5 1-6 1
Oxygen (%)	40-46	34-39	31-34
Nitrogen (%)	0 5-1 0	0 8-1 1	0 9-1 9
Sulphur (%)	0 1-0 2	0 1-0 3	0 2-0 5

Table 1. The function of humification in peat elemental composition percentage [35].

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Organic material	H 1 to H 2	H 5 to H 6	H 9 to H 10
Cellulose (%)	15-20	5-15	-
Hemicellulose (%)	15-30	10-25	0-1
Lignin (%)	5-40	5-30	5-20
Humic acids (%)	0-5	20-30	50-60
Bitumens (%)	1-10	5-15	5-20
Nitrogen compounds (%)	3-14	5-20	5-25

Table 2. Percentage of different organic material components in peat of several humification degrees on dry basis [37].

	Sedges		Mosses		Forest	
	Plant	Peat	Plant	Peat	Plant[a]	Peat
Ether-soluble	1-3	1-3	1-5	2-6	4	3
Water-soluble	3-13	2-3	4-8	ND[b]	15	N[b]
Hemicelluloses	12-31	0	21-25	12-19	17	3
Lignins[c]	21-42	38-46	7-12	25-52	30	61
Proteins[d]	4-15	22-23	4-6	5-6	3	14
Ash	3-5	10-13	3-4	1-2	5	4
Total	93-98	88-91	73-86	73-87	90	90

Note: (a) Oak leaves, (b) ND not determined, (c) including humic acids, (d) assuming all nitrogen present to be protein (i) bitumens.

Table 3. Comparison of peat plants and peat soils (%, dry basis) [35].

The dissolved part of peat includes bitumens that are soluble in hot and nonpolar organic solvents.

The ascending amount of bitumens and ascending decomposition of peat is shown below **Table 3**.

The main carbohydrates in peat are pectin, cellulose, chitin, and lignin which are explained in detail below [35].

- Pectin is an extraction from peat using hot water and has a 1, 4-α bonding linkage and a galacturonic acid unit linear chain as shown in **Figure 1**.

- Hemicelluloses are composing the biggest part of peat. The original source of hemicelluloses is taken from plant or microbial sources. Hemicellulose has between 200 and 300 sugar units which compose long chains of glucose, fructose, mannose, galactose, rhamnose, arabinose, xylose, galacturonic acid, and glucuronic acid. Water is not used as a solvent for cellulose. Cellulose is a linear polymer of glucose and contains approximately 10,000 sugar units bonded with 1,4-P linkages, shown below in **Figure 2**.
- Chitin is a linear polymer of N-acetylglucosamine and is determined in the cell walls of fungi as shown below in **Figure 3**.

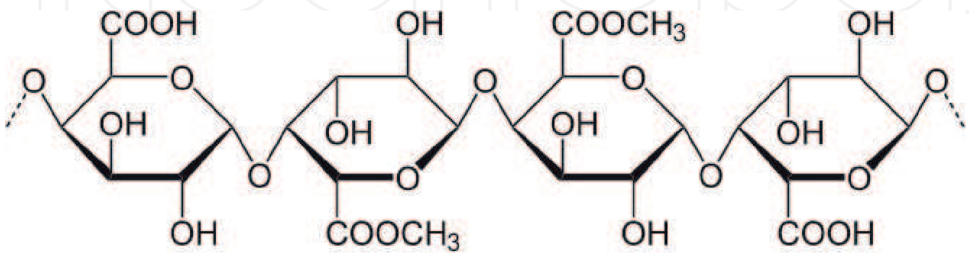

Figure 1. Pectin chemical structure [35].

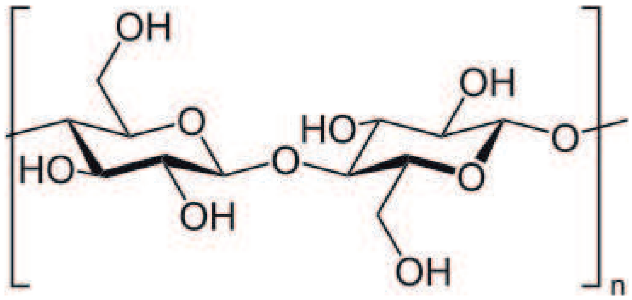

Figure 2. Cellulose chemical structure [37].

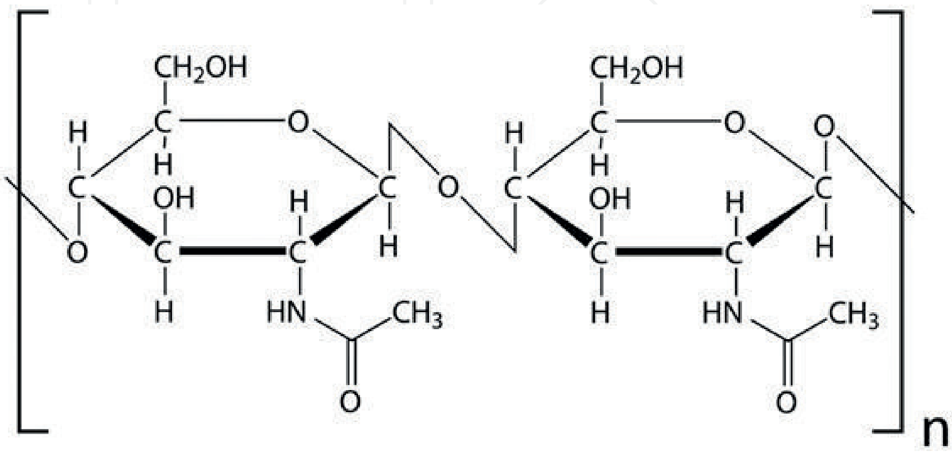

Figure 3. Chitin chemical structure [36].

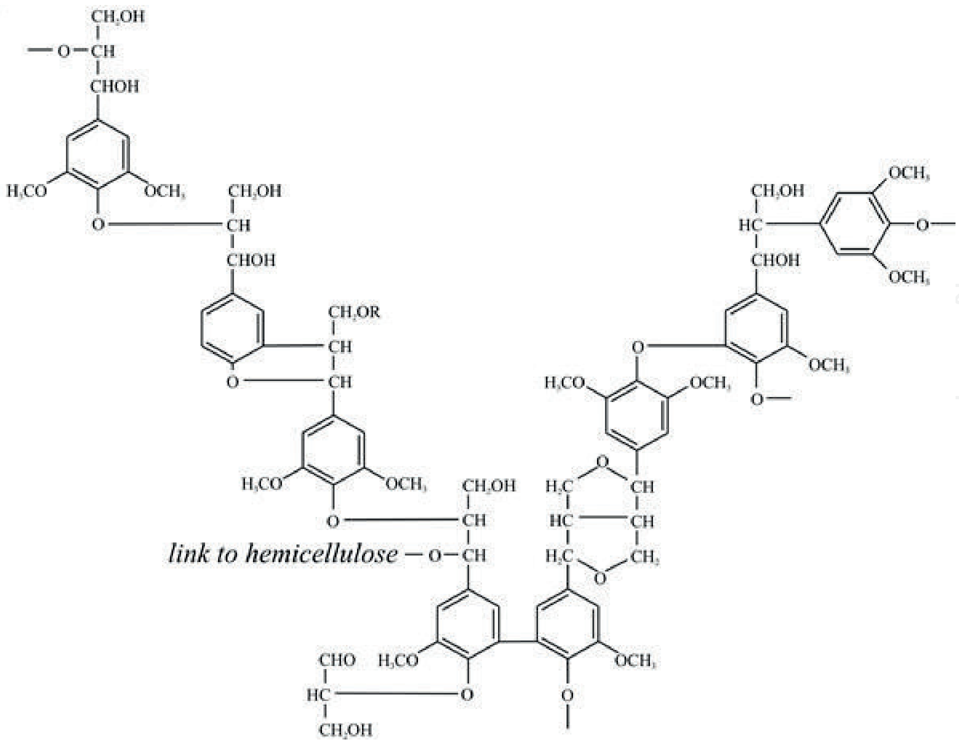

Figure 4. Lignin chemical structure [36].

- The main part of the structure of lignin is shown below in **Figure 4** and called as phenol, composed a chain of n-propyl in para position and a group of methoxyl in one or two ortho positions. The parts of lignin are arc linked in different ways to compose a structure of macromolecular complex. The main aim of lignin is to protect the plant from biological attack by microorganisms. The decomposition degree effects the proportion of lignin in an ascending way about the decay resistance of lignin.

7. Peat as a substrate in horticulture

The destiny of the nursery and greenhouse production is related with the growing media quality. In the production of media for plant growth, there have been used several combinations of inorganic and organic components. The peat is used not only for greenhouse and nursery production but also for gardening at home (**Figure 5**). In the history, the most used organic material was peat which is extracted from peat lands from decomposed plant matters that have poor drainage.

In vegetable growing, it is aimed that the product is productive, high in quality, and healthy in terms of human nutrition. In order to achieve these goals, factors such as the selection of appropriate varieties, the use of quality seeds, and the cultivation of healthy and quality seedlings are important. The medium in which seedlings are growing is important in healthy

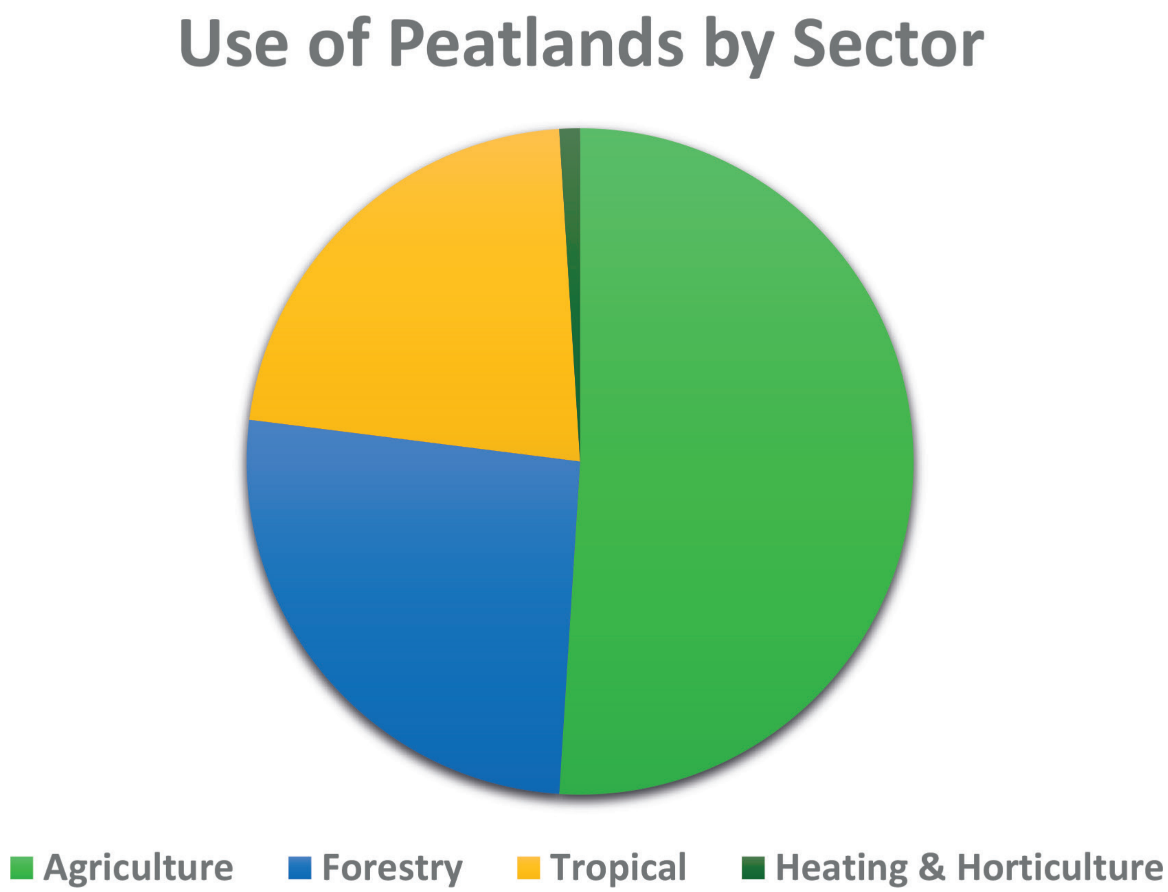

Figure 5. Use of peat lands by sector (https://www.gardenmyths.com/peat-peatmoss-true-story/).

and high-quality seedling production. Costs must be low for these used mediums to be advantageous to manufacturers. Mediums are used for seedling growing, seed germination, emergence rate, rate of growth, and quality of the seedlings. When seedlings are grown in unsuitable mediums, they may experience problems with germination and increase seedling cost with inadequate germination. In addition, since the seedlings are late planting, the growing period is delayed, the harvest is delayed, the yield decreases, and seedling deaths occur after planting and during planting. For all these reasons, it is necessary to pay attention to the selection of the environment to grow seedlings. Many different mediums and mixtures of them have been used in growing seedlings in recent years, especially peat. Mostly, peat is used in seedling cultivation in Turkey [38].

In extensive agriculture for a fast production and increasing the profits of sales, ornamental plant nursery production can be the best example which commonly uses the nonrenewable resources. According to imperfect management applications, the green industry is seen as a polluting industry. But the most spread media for ornamental growth in Mediterranean is peat due to its better chemical and physical characteristics [39].

The peat is an unabandonable substrate in horticultural industry till now, and environmental impact will prove the usage of peat will continue in the sector due to its high demand and need [40].

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In the horticulture industry, the peat has three different forms that are commonly used as peat humus, moss peat, and reed-sedge. The moss peat is generally taken from sphagnum moss. The minimum decomposed type of peat is called as peat moss which is light tan to brown in color, is lightweight as 6.5 lbs/yd3, has high moisture and holding capacity and acidic conditions between pH 3.8 and 4.3, and due to these properties, it has a clear and proper fluffed structure. Peat moss is a common sample on a volume basis as an example 50% peat moss:50% perlite, vol:vol. There are significant differences between sphagnum moss and peat moss due to sphagnum moss's live portion or young residue of the plant. In plant shipment, to line hanging baskets, and in propagation, the most used matter is sphagnum and there are some efficient substances in sphagnum to inhibit the fungi growth related with damping off. The most common peat form in Florida is the reed-sedge peat which is extracted from reeds, sedges, cattails, marsh grasses, and other associated swamp plants. In common, the reed sedge and hypnum moss are used to derive peat humus which provides a better level of decomposition and has generally dark brown to black color and a low capacity of moisture retention. In seedling production in containers, peat is also a major constituent for substrate. The greenhouse growth transplants are the crucial parameter for optimizing the production systems and directly affect the production phase in the field [41]. The greenhouse growth transplants have many good properties like early production, robust, uniform growth, and healthy root systems [42].

The most common applied method is the use of transplants in small cell production using peat-based media [43].

In horticultural production of fruity vegetables like cucumber and bean, the preferred medium is solid substrate all over the world. The EU, US, and Canada used solid substrates for the estimation of growth of approximately 95% of greenhouse vegetables to be produced [44]. Rock wool (RC) and peat are the main components that are used in solid substrate cultivation, conventionally [2, 45–47].

There have been several studies conducted on pepper growth with soilless substrate on the parameters such as growth, quality, and quantity after studies on tomato. The media for pepper growth were several such as perlite, soil, sand, peat, and pumice. The effects of media components on the yield, weight of pepper fruit, ascorbic acid values, and total soluble solids were studied. When all media were compared, the peat was found to be the most efficient for plant growth with higher ascorbic acid content, total soluble solids, fruit number per plant, and yield on pepper. The potassium ratio was found higher in peat when compared with the other media [48], and it is reported that this higher potassium rate can increase the vitamin C in plants [49]. When a comparison was made between only-peat substrate and peat-perlite and peat-zeolite substrates, the biggest leaf area was determined in seedling growth in only-peat substrate; however, the dry material content was not much in leaves when compared with the peat-perlite and peat-zeolite substrates [1].

In the EU, the reported total amount and ratio of peat in media for plant growth is 25,990,000 m^3 equaling 75.1%. The main reason for this high percentage is long experience of countries on peat production and their high resources. The usage ratios of peat by country are as follows: 99% in Estonia, 99% in Lithuania, 92% in Latvia, 88% in Finland, 87% in Ireland, 87% in Denmark, 87% in Sweden, and 81% in Germany [50].

8. Disadvantages of peat

In the recent decades, the decreasing usage of peats brought the ascending prices and costs and also produced some hesitations if it will have an impact on environmental problems. Indeed, the mining of peat from very high fragile ecosystems may cause a potential degradation of natural habitats of biodiversity and living organisms. For wild animals and plants habitat, peat has a crucial importance to develop the quality of groundwater, and furthermore, it preserves the CO_2 sinks. So the intensive use of peat in horticulture industry may cause the release of CO_2 from these ecosystems as it is a nonrenewable source. Due to this, global warming may increase and a global movement should be started to success a sustainable peat and an intelligent wetland usage. The growing requirement and need of soilless media for horticultural industry causes to find new media for plant growth from organic wastes instead of peat as a nonrenewable source and its ascending concerns for environment. During the last years, there has been an increased concern about the use of peat. Many peat bogs are characterized as special areas of conservation. The number of license for peat extraction has decreased in order to protect environmentally significant peat bogs. Pressure of environmental groups has increased in order to reduce the use of peat by growers. Government has set as target that 40% of the total market demands, for growing substrates and soil improvements, should not be covered with peat-reduced or peat-free products, by 2004. In 1999, 36% of the market was covered by peat alternatives. Some of peat alternatives may include wood residues, forest harvest materials, urban wastes, composts, and other industrial wastes. Scientists have made several experiments to test peat alternative substrates [1].

Scientists all over the world examine the potential peat alternative substrates and the disadvantages that may have, when compared to peat. Evaluation of water and nutritional consumption is very important for peat alternatives. The use of peat alternatives is going to expand in many different horticultural sectors. An experiment which took place in Chile tested the use of vegetable wastes with melon as a substrate [51]. The compost of vegetable waste was compared to coir and rock wool as far as it concerns yield and quality of melons. The vegetable had satisfactory results only when it was leached prior use, otherwise high pH and salinity occurred.

Since the pressure for adopting new growing media alternative to peat is steadily increased, it is almost sure that sooner or later the use of peat alternatives is going to increase. Some supermarkets have given instructions to the growers that in order to keep buying from them, they should limit the use of peat. The reduction of peat use may increase the cost of horticultural production. In order to further decrease the peat in horticulture, further research is required for disease, nutrition and water management, and storage characteristics. Finally, further research could be done so as to determine the optimum substrate for each plant. One of the main issues of peat is wetting again the medium when it becomes dried. Because of that, synthetic agents are used in general in peat-based media to fix the problem [52].

9. Conclusion

Container-grown plant substrate mixtures are very important for the production of nursery and greenhouse plants. There have been several studies conducted on horticulture plants

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with soilless substrate on the parameters such as growth, quality, and quantity. Peat has been used for successful cultivation of different vegetables and ornamental crops in soilless culture since the early 1900s. Peat has important functions for plant. It keeps water and nutrients and gives them steadily to plants. It has air pockets or pores to supply oxygen to plant roots and to allow for drainage. Because of the several disadvantages, the use of peat alternatives is going to expand in many different horticultural sectors.

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